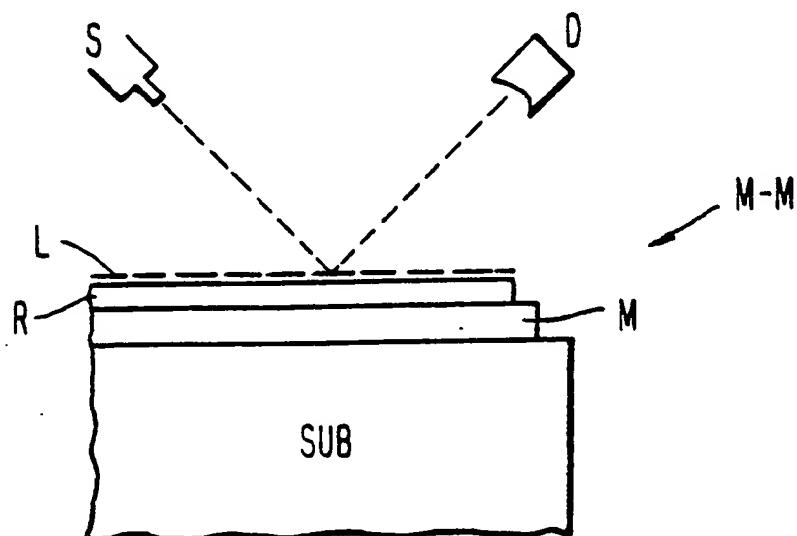




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(71) Applicant:	UNISYS CORPORATION [US/US]; P.O. Box 500, Blue Bell, PA 19424 (US).	
(72) Inventors:	BERTI, Eugenio, F. ; 6259 Mojave Drive, San Jose, CA 95120 (US). HERTE, Lawrence, F. ; 399 Matadero Avenue, Palo Alto, CA 94306 (US).	

(54) Title: MAGNETIC DATA STORAGE MEDIA



(57) Abstract

Embodiments disclose magnetic recording compositions (e.g., as coated on a rigid data disk or like substrat), particularly organic particulate compositions with thin metallic overcoatings for such.

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TITLE

MAGNETIC DATA STORAGE MEDIA

This invention relates to magnetic recording compositions (e.g., as coated on a rigid data disk or like substrate), and more particularly to organic particulate compositions and to thin metallic overcoatings for such.

BACKGROUND, FEATURE OF INVENTION

Workers in the art of making and using magnetic recording apparatus for data processing and the like are well aware that the media therefor often present serious

wear problems, such as may foreshorten their useful life. For instance, with rigid polymeric-particulate magnetic recording disk surfaces which support a thin-film magnetic recording head (carried on a "slider") passing at relatively high speeds, the head is all too apt to problematically be abraded, as is the medium.

A related problem is that of undesirably high friction between the disk and head (surfaces). To ameliorate abrasion, workers typically specify that a disk coating exhibit no more than a certain coefficient of friction -- this also reduces the force necessary to drive the disk past the head. To reduce friction and enhance wear, workers have resorted to various expedients, such as "surface lubricant" (liquids such as fluorocarbon or dry lubes like MoS₂ or carbon-graphite) coatings on the disk's recording surface.

20

25

30

BRIEF DESCRIPTION OF THE DRAWING:

These and other features and advantages of the present invention will be appreciated by workers as they become better understood by reference to the following 5 detailed description of the present preferred embodiments which should be considered in conjunction with the accompanying drawing;

FIG. 1 is a schematic sectional showing of one embodiment; FIG. 2 is a like showing of a modified embodiment.

10 The invention will be better appreciated by workers upon consideration of the following detailed description of some preferred embodiments.

DESCRIPTION OF PREFERRED EMBODIMENTS--General description, background:

15 Example AA illustrates a magnetic recording substrate disk coated with a recording composition, with a lube system formulated and applied thereon as known in the art.

20 This, and other means discussed herein, will generally be understood as selected, formulated, and operating as presently known in the art, except where otherwise specified. And, except as otherwise specified, all materials, methods, and devices and apparatus herein will be understood as implemented by known expedients 25 according to present good practice.

Following is a specific Example of such a 30 polymeric particulate surface, apt for use with the present invention. This composition is prepared to include the mentioned components in indicated concentrations, and to be applied, processed and used as indicated.

Ex. AA: Typical polymeric particulate record surface:

A relatively conventional magnetic record polymeric particulate coating will be understood as disposed on a rigid computer disk, with a surface lubricant layer applied thereon. More particularly, a Winchester aluminum disk record is coated with a polymeric particulate magnetic recording film (magnetic oxide in polymeric epoxy-phenolic type binder) for Write/Read operations with an associated flying recording head-slider.

The acicular magnetic oxide particles are mixed into a binder of epoxy, containing alumina particles as well. This mixture can present a heterogeneous surface of hard particles and "less-hard" binder to a passing slider, with the hard particles resisting abrasion by the "similarly-hard" slider. The record surface will be assumed to have been finally treated (e.g., polished, burnished, degreased, rebaked and otherwise fully treated).

A fluorocarbon polymeric "lubricant" is applied on the recording surface of the polymeric coating.

Embodiment A: Optical Super-Coating

FIG. 1 may be understood as representing a recording medium M-M of the kind above-described, including a thickness M of magnetic particulate oxide deposited on a substrate SUB (e.g., aluminum Winchester disk as known in the high speed digital data disk recording art), smoothed to mirror-smoothness and covered by a high reflectivity optical film R.

Magnetic recording coating M may comprise any suitable thickness of related magnetizable material;

here, preferably a dispersion of magnetic particles such as gamma ferric oxide or chromium dioxide, dispersed in a compatible medium; e.g., preferably a polymeric epoxy-phenolic type binder.

5 Record thickness M may, in general, be constituted as with known disk media in the high speed digital data recording art; however, as will become more apparent below, its polymeric (e.g., epoxy binder) constituents may be modified somewhat. Moreover, the
10 usual wear-resistant ("hard") pigment, such as Al_2O_3 particles, may be radically reduced, or even eliminated, when a wear-resistant super-coating R is applied to the recording surface. The alumina particles can be replaced (at least in part), for instance by more
15 magnetic pigment (cf. a 10% to 20% higher loading of magnetic pigment here). And the polymeric matrix need no longer be wear resistant or resistant to slider heating and "pickup"; thus chosen to exhibit relatively low toughness, with little need for much cross-linking, etc.
20 As a result, workers will contemplate savings in polymer materials, thickness and related treatment.

Atop magnetic thickness M is a high-reflectivity, mirror-like optical recording film R on which optical data indicia may be recorded (e.g., see laser source S)
25 and read-back (e.g., see associated detector D), at a suitable energy and wavelength, as known in the art.

In certain cases, a hard protective transmissive layer H will be super-coated over optical layer R; a somewhat conventional layer L of lubricant may be

superposed on H or on R. However, in this embodiment, the protective layer H will be dispensed-with for purposes of simplicity of explanation. In many cases, workers will want to provide an optical layer R which is also 5 adapted to be sufficiently hard and mechanically stable, etc. to serve as its own protective outer surface layer (for periodic, or occasional engagement with a magnetic slider or the like). In certain cases, optical recording layer R may exhibit other optical recording characteristics 10 (other than reflectivity, e.g., change in index of refraction).

In any event, workers will understand that (as with the usual like magnetic medium and associated lubricant), a magnetic slider (not shown but well 15 understood in the art) will be understood as intended to periodically make contact with lubricant L on the outer surface of this multi-layer recording medium M-M. One example is the Memorex 3680 magnetic disk drive and its associated disks, sliders, lubricant, etc.

As a salient feature hereof, optical layer R may 20 be relatively conveniently provided in the form of a high-reflectivity metal layer; preferably a thin film of aluminum, chromium or gold metal, or alloys thereof, sputtered-deposited atop the indicated magnetic thickness M (e.g., to a depth of 200-300 Angstroms, or 25 about one microinch). More particularly, we found that aluminum (99% pure for high reflectivity) may be sputter-deposited successfully onto a 3680 magnetic oxide surface. For instance, the following conditions are quite 30 suitable:

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TABLE A

Aluminum target on an 8" diameter cathode:

Voltage: 390 VDC

Current: 5.0 amp

5 Sputtering method:

D.C. magnetron

Sputtering gas:

Argon at 10 mTorr

Target to substrate:

10 Distance 5 cm.

Pump down vacuum prior to processing:

< 5×10^{-6} Torr

Other conditions as in normal processing, e.g.,
room temperature.

15 A preferred type of optical data writing is by
ablative laser "opening" of a hole, or "pit", in the
highly reflective coating R to reveal the lower-
reflectivity particulate media surface below. We find
that a 2 watt argon laser is suitable to ablate a pit in
20 the aluminum film measuring about 1 micron diameter. By
using an acousto-optical modulator, a pattern of
(somewhat circular) holes can be written about a
circumferential track as the disk medium rotates. The
laser-formed hole pattern can embody data-encoding that
25 can be subsequently "read" to accommodate servo positioning
of the magnetic read-write head. These holes can be
recorded directly over related magnetic information, or
between data tracks -- e.g., being on, or adjacent to,
the data track of interest (e.g., for controlled-centering
30 of Read-head).

A light (e.g., a few monolayers, about 50 A° on our 250 A° thick aluminum film) thickness of oxide will naturally form on the Al, but should present no problem (cf. chromic acid "anodizing" is best avoided; it will 5 usually "pit" the Al, spoiling its reflectivity and contributing to "noise").

Under such read/write conditions we find that such an optical layer R should have a native ("virgin, unwritten") reflectivity of greater than about 50%, 10 preferably about 60% to 70% for 550 to 850 nm, with a written reflectivity change adapted to facilitate read-back (e.g., a ΔR of about 30-50% is preferred). Layer R will preferably comprise about one microinch here (250 A°; e.g., so as to limit head-disk spacing loss of 15 magnetic signal strength to about 10%). It turns out -- somewhat surprisingly -- that the usual "3680" magnetic disk coating M is quite apt for such optical recording (i.e., offering an optical "background", under R, of acceptable contrast for read-out). It also turns out -- 20 also a surprise -- that the mentioned "3680" magnetic disk coating M is sufficiently smooth (after the usual polishing) that the described 250 A° (preferably 200-300 A°) of aluminum so sputtered goes down as a high reflectivity "mirror surface" that is quite suitable for such laser recording (e.g., about 70% reflectivity at the indicated preferred 820 Nm. laser wavelength -- note: up 25 to about 10,000 A°, the sputtered film will closely follow and conform to the "topography" of the substrate). Moreover, it bonds surprisingly well to this magnetic

disk (epoxy, etc.) surface (cf. presumably sputtering Al into the body of the binder). For instance, it easily resists the "Scotch tape" test, as well as the bonded-stud type "Pull-test". Such an Al film may, in 5 certain cases, be laid down by CVD (chemical vapor deposition) techniques also; however, thermal evaporation deposition is disfavored because of poor adhesion.

The natural formation of an oxide layer on a bulk aluminum surface will, under typical conditions (in air) 10 build up until you have a 50 A° oxide (e.g., on 1 microinch thick aluminum) film. The metal film with oxide remains metallic in appearance (when exposed to air). Auger depth profiling indicates that a layer of oxide 50 A° thick forms on the 1 uin. thick aluminum film and the 15 growth of the oxide layer will stop when air no longer adsorbs onto fresh aluminum -- probably after two monolayers of aluminum, or after five monolayers (50 A° or 1/5 of a microinch) of oxide have formed. For a one (1) uin. aluminum film, you can expect a 1/4 uin. 20 oxide to develop, leaving about 4/5 uin. of pure-aluminum metal underneath.

Now, some workers will be satisfied using such an aluminum supercoating coated with a suitable lubricant (such as the mentioned liquid fluorocarbon or dry 25 carbon-graphite) for recording with a slider (e.g., 3680 type). In fact, wear tests with a mini Winchester type slider "normally-loaded" (15 gm) on a 3680 disk, with a one u" aluminum film sputtered thereon, and a normal one u" dry carbon lube coat, give rather poor results (e.g., 30 less than 3300 start/stop cycles).

However, the hardness of such sputtered aluminum is in the "moderate to low" range (about 2 MOH) and will not stand up under prolonged, heavy-duty slider contact; for instance, we found that such an aluminum layer, so
5 coated with graphite-lubricant, would satisfactorily endure only about 3200 "Start/Stop" cycles with such a slider (before "wear tracks" appear); whereas workers look for about 10,000 Start/Stop cycles or more (note:
10 with no lube at all, the Al film galls on the ferrite slider, which refuses to even "take-off").

Thus, we infer that aluminum is a less desirable sliding surface for a recording head slider and will need lubrication. Production type 3680 rigid disks are typically wet-lubed (liquid fluorocarbon applied on
15 surface) to afford good wear resistance; thus our aluminum coated 3680 disks here are given this wet-lube. The lubed aluminum-film disks nonetheless failed standard wear tests again, probably because of the low
20 hardness (Mohs of 2) of the 1 microinch Al film (where the aluminum is indented by slider).

--Results:

Workers will recognize several advantageous characteristics of such a two-level recording medium (having optical record atop magnetic record); for
25 instance, the optical layer R can evidently provide disk servo data which is positioned directly atop related magnetic data bits. For instance, a certain magnetically recorded data field may be identified by related superposed optical pits, which may also provide sectorial

information, disk rpm, disk track number and even track-centering where desired, as known in the art. A "Write once (initialize), Read-only" mode of servo recording on this optical film is well suited to such an arrangement (e.g., almost any power laser can be used as the read-laser).

Workers in this art have long hoped for such close physical correlation of magnetic bits with servo and like indicia, without using-up magnetic record areas ("overhead"). This may be compared, for instance, to the conventional practice of locating such (servo, etc.) indicia on a separate disk face (in a stack of magnetic disks) and worrying about whether it "wanders" from its original precise positional-correlation with related magnetic bits (on other disks); e.g., whether this correlation will remain constant despite temperature cycling, with different expansivities, despite spindle variations, etc -- especially where the disk pack is "removable".

And where such indicia (e.g., servo) is "embedded", or otherwise recorded on or between magnetic data tracks, it is not only somewhat chancy to "locate" but adds to "overhead" and so reduces magnetic data storage area.

The present need to increase areal storage density, as TPI increases, makes "embedded" servo indicia less and less desirable.

Workers will notice that such an aluminum overcoating, between the usual polymeric magnetic layer M

and its lubricant L, also introduces changes in the necessary characteristics and functions of both layers (magnetic and lubricating). For instance, the lubricant must now be formulated to protect the slider from damage by the metal (aluminum) optical layer R and vice versa. The lube must also be formulated and applied so as to be retained on the aluminum surface, and not be "spun off" or otherwise depleted. Solid-film lubricants like molybdenum disulfide or graphite films should be satisfactory; however, when applied directly to the aluminum film surface, no improvement in wear-resistance is obtained due to the dominant "softness" of the reflective aluminum layer.

In addition, the reflective quality of the aluminum layer may be adversely affected by the lubricant and any subsequent wear caused by the slider. In such a case a hard protective layer H may be added (FIG. 2); layer H should be selected to provide: wear resistance to the reflective aluminum film and underlying magnetic media; a barrier to shield the aluminum film from any reduction in reflectivity due to subsequent lubrication or the atmospheric environment (e.g., tarnish of Al); a suitable homogeneous substrate surface able to enhance lube retention or promote the lubricating action of solid-film lubricant; a uniform, relatively "hard" surface for accommodating contact by the slider without comprising slider wear-resistance.

Similarly, magnetic layer M is now radically changed in function (vs. conventional situation): it

will no longer be directly contacted by the slider or the lubricant layer; although it must be compatible with providing a relatively rigid mirror-smooth substrate for reflector layer R, it must bond firmly therewith and it must tolerate associated sputtering temperatures and other fabrication conditions.

The thermal-magnetic characteristics of Fe_2O_3 (acicular, iron-oxide) particulate media (like that of 3680) is well suited to the subsequent sputtering process, in that it is unaffected by related process temperatures (up to 200° C). "Magnetite" (Fe_3O_4 vs. Fe_2O_3 or "ferrite") would likely undergo some magnetic degradation at these process temperatures and be less suitable. The surface smoothness of the polished magnetic media should be better than 1 microinch as measured with a profilometer.

The application of a satisfactory wear-resistant super-layer R will allow changes and improvements in the formulation of the underlying magnetic layer composition.

Thus, for instance, the amount of relatively conventional wear pigment (Al_2O_3 particles or the like) may be reduced, or dispensed with, and substituted-for by magnetic pigment -- thus increasing the density of magnetic oxide (% loading) and favoring higher bit density, with fewer write-errors (e.g., Al_2O_3 particles can produce "lost" bits). Similarly, the polymeric binder need no longer have the toughness and related slider-wear characteristics and may be accordingly reformulated with greater freedom and different performance requirements.

--Alternatives:

Instead of sputter-deposition, the aluminum may be deposited by ion plating, or CVD, or other means providing acceptable film adhesion. Or, other like 5 high-reflectivity metals may be substituted. For instance, chromium may be similarly sputtered onto such a magnetic surface (and is very corrosion-resistant); similarly for non-magnetic nickel, rhodium, platinum, vanadium and the like; even "refractory" material like 10 tungsten, molybdenum or hafnium may be substituted in certain instances. Some metals like tellurium are less suitable because they tarnish. Also, certain related alloys will be apt (e.g., for laser write-ability), for instance "hard" gold alloys, where protected by 15 supercoat H.

Use of a flexible substrate, such as tape, diskettes, or film strips, is quite feasible; but it will typically call for slower processing and special cooling to avoid thermal distortion of the substrate. In some 20 instances, record layer M may comprise a magnetic metal. In such a case, one may resort to making its surface highly-reflective or otherwise suitable for optical recording. When such is not feasible, an optical film R may be resorted to. In any case, where the optical record 25 surface is not sufficiently "hard" or otherwise needs protection, a protective supercoat like film H may of course be used.

--Ex. A-1: as A, but substitute Cr

Ex. A is replicated, with chromium substituted 30 for the aluminum reflector film R; preferably the Cr is magnetron-sputtered (e.g., to a thickness of about 200-300 Å°). The Cr reflector will be adequate for

optical purposes but not as reflective as aluminum; however, it is more highly adherent, is harder, and may allow a thinner wear resistant coating; also it is more corrosion-resistant, and better able to dispense with
5 supercoat H.

Preferably, the Cr is coated with a liquid slider-lubricant like fluorocarbon. Dry carbon lubricant exhibits higher friction than fluorocarbon on such bare metal films at high linear speeds (> 500 Ips).

10 Example B: as Ex. A, but add SiC supercoat

Example A is replicated; however, the reflective optical layer R is supercoated for increased hardness and wear-resistance (vs. slider) with a thin, hard, light-transmissive protective film H, preferably
15 comprised of silicon carbide or a like protective material. The impact of slider-landing tends to score the metal film, thus prompting the use of a harder film protecting the metal layer.

20 More particularly, it has been found surprisingly effective to sputter up to several hundred \AA SiC immediately following deposition of the reflective sputtered-aluminum layer in the same sputter chamber.

Results:

25 Hardness and wear resistance (vs. slider) are increased radically; for instance, so that the medium M-M will sustain at least 20,000 Start/Stop cycles without perceptible track wear. The thickness of SiC should not interfere with (be translucent to) the laser read-write operation; about 150-250 \AA is found satisfactory with an
30 850 Nm. laser light source. Of course, the added thickness will necessarily displace the read-write

transducers that much farther away from the magnetic oxide (layer M) and accordingly degrade output signal amplitude (e.g., about 10% degradation for each microinch). Also, as SiC thickness increases, it soon
5 reduces read-laser transmission; e.g., passing only about 60% of the preferred 820 Nm. beam at about 400 A° thickness.

The SiC is preferably sputtered under roughly the same conditions as Al film R, but using RF diode
10 sputtering equipment, although, as with any dielectric, the rate of (SiC) deposition is relatively slow.

The SiC coating provides a homogeneous layer, as opposed to the particulate-in-epoxy binder surface. This results in more uniform distribution of liquid lubrication
15 and expected lube retention. The highly adherent, vacuum-deposited SiC layer also provides a suitable substrate for subsequent carbon-lube deposits (cf. can epitaxially-influence crystalline carbon formulation). In addition, the SiC coating protects the aluminum film
20 from tarnish, etc. and associated loss of reflectivity.

As workers may realize, silicon carbide is considerably harder than Al (13 Mho; vs. about 2). The bare unlubricated silicon carbide surface was tested under a thin film (TF) slider; but offered relatively
25 "high" friction and the slider soon "crashed" (e.g., within 1800 S/S; compared to the "moderate" friction of a standard 3680 disk surface).

But, rather surprisingly, when coated with dry carbon (e.g., 100-200 A°, preferably sputtered), the silicon carbide surface exhibited "unexpectedly-low" friction. Similar results are seen with a dry molybdenum

di-sulfide film; however, vacuum deposited carbon is preferred.

This was especially surprising since a like 1 microinch film of carbon, or molybdenum di-sulfide, on 5 "bare" 3680 particulate (polymer) surface exhibited "high" friction (though, at about 20 u", carbon shows lower friction; however, this is much too thick for present purposes; e.g., degrading read-out almost 100%).

We prefer to limit the "head dislocation" 10 distance D_h (added distance between head gap and magnetic oxide) to 1 u" to 2 u" (225-450 A°), cutting output 10-20%; thus, we prefer film thicknesses as follows:

TABLE I

15	Reflector film (e.g., Al)	150 A°	(100-200)
	Wear film (e.g., SiC)	150 A°	(100-200)
	Surface lube (e.g., C)	<u>150 A°</u>	<u>(100-200)</u>
	Total D_h	450 A°	300+ A°

Workers may be surprised at the superior 20 durability of such an Al-SiC-C combination. With wear tests of the type aforementioned, a one (1) u" Al sputtered onto 3680 disk, with surface lube of dry carbon gave less than 3300 Stop/Start cycles; it showed surprising, unexpected improvements in wear when the 25 hardness-supercoat H is superposed as a thin sputtered SiC layer (150-250 A°) above the Al, yielding better than 10,000 Start/Stop cycles.

Thus, we teach that adding a thin overcoat (e.g., 30 sputter 150 A° or more) of silicon carbide, or the like, will greatly enhance wear-resistance of the mentioned Al-coated particulate-polymer disk.

Alternatively, chromium may be used instead of aluminum to overcoat the polymer-particulate. Cr can also be sputtered by D.C. magnetron techniques for high deposition rate. The carbon wear-film (or MoS₂ or WC) can be sputtered using D.C. magnetron; however, the SiC requires R.F. sputtering (sputter parameters can be the same; a "self-bias" of about 1500 V produces an acceptable deposition rate of 300 Å/minute).

--Alternatives:

Instead of SiC, various glass-like materials may be used as a wear-film, e.g., like sputtered-garnet (only the sputtered form) or other oxides. However, some "glasses" such as amorphous silica (SiO, SiO₂) will likely be too "soft". Sputtering an aluminum oxide coating is even slower and less practical (for discussion of an attempt at electroplating an aluminum overcoating and oxidizing that, see IBM TDB, volume 27, No. 12, May 1985); and the hardness is less than SiC.

A steatite composition (soapstone) was also sputtered on such a substrate, but found to present high friction in the thin film (low stop/start capability). Other materials may, in certain cases, be substituted for silicon carbide, such as tungsten carbide or other carbides. And, instead of sputtering, such materials may be deposited by chemical vapor deposition (e.g., plating a hard metal onto the aluminum layer would not yield the extreme hardness desired), or other suitable known techniques.

As another variant, the protective coat H may also possess optical recording qualities (e.g., made low-reflectivity, to be pierced at "bit-site" exposing high-reflectivity film R underneath).

Example C: as B, without optical layer R

5 Example B is replicated except that the optical layer R is dispensed-with, and the SiC, etc. is sputtered directly onto the magnetic oxide layer M, to thereby create a protective layer on which the read-write slider may ride. It is found -- somewhat surprisingly -- that the SiC layer so sputtered will bond very well with the magnetic oxide film primarily due to the high kinetic energy of the arriving SiC molecules.

10 Glass or other soft dielectrics would not be a good substitute for SiC because not hard enough, e.g., when deposited directly on the polymeric film.

--Results:

15 Are comparable to those described above, except of course with the overall metallic thickness atop the magnetic oxide being less (e.g., about 150-250 Å° here), output signal degradation will be less (that is, on the order of about 10% total).

20 Over 20,000 Stop/Start slider cycles are possible with the SiC (e.g., properly lubed, such as with carbon) with no apparent damage to the medium SiC coat or to the slider head.

25 Since there is no optical layer here, one might alternatively etch holes in the surface of the SiC for retention of lubricant, such as with the IBM 3380 disk (should this become a problem) without affecting the magnetic layer.

30 SiC, or a similar hard supercoat, can also be beneficially used on a plated disk or plated magnetic tape surface having considerable head contact or sliding wear; the preferred (plated or sputtered) magnetic film subject would be Co-Ni-P. Sputtered thin film magnetic disks or tape would also benefit from the application of the SiC supercoat.

By way of reprise, please note that we here teach:

--covering a magnetic recording film M with a thin non-magnetic metal film R, particularly a polymeric recording film M_p , whether for optical record or anti-wear purposes (e.g., vs. slider contact), or both;

--and, where film R is for optical recording, it may involve a high-reflectivity metal like aluminum, chromium or the like,

--in particular, we find it attractive to sputter 10 Al or Au onto a "plastic" material like the "3680" magnetic oxide-in-epoxy; to our surprise such an Al or Au film is quite adherent, even when so sputtered. But a relatively "hard" sputter vacuum is preferable (e.g., MIN 10^{-6} psi for Al, 10^{-5} for Au, along with adequate 15 voltage). It is quite a surprise to adequately adhere either Au or Al to epoxy -- as workers know "noble gold" doesn't stick well to most materials. By contrast, neither Al or Au gives "good" adhesion to 3680 when deposited by (thermal) vapor deposition, even under a 20 "hard" vacuum [cf. initially Au is "blue", so enough must be deposited to give good reflectance],

and where such an optical recording film R_o is susceptible of surface wear (e.g., by slider) and/or other degradation (e.g., loss of reflectance via tarnish, 25 etc.), it may also be overcoated with a thin film of relatively "hard" non-magnetic layer H (e.g., SiC), made thin enough to "pass" the involved read/write optical beam.

[Cf. particularly sputtered SiC on sputtered Al 30 or Cr].

--where film R is only for anti-wear purposes, it may of course be simply comprised of a relatively "hard" layer, like SiC.

In any case, we prefer the hard overcoat surface, where used with a contacting slider, to be coated with suitable lubricant. In many cases, we prefer a dry solid surface lubricant, such as carbon (sputtered); otherwise a "wet" lube is needed (e.g., a fluorocarbon). Of course, the carbon-lube film is preferably kept "light" (e.g., up to a few hundred Å; more is apt to degrade lubricity and faster "stiction", etc.). Also, in some instances the carbon film may provide "optical shutter" qualities, e.g., being highly absorptive of the optical beam so that when "pierced" (e.g., ablated away), it may expose an underlying reflector and thus form a "bit site".

Conclusion:

It will be understood that the preferred embodiments described herein are only exemplary, and that the invention is capable of many modifications and variations in construction, arrangement and use without departing from the spirit of what is claimed.

Further modifications of the invention are also possible. For example, the means and methods disclosed herein are also somewhat applicable to flexible media and the like. Also, the present invention is applicable for providing metallic super-coatings on media for other forms of recording and/or reproducing systems.

The above examples of possible variations of the present invention are merely illustrative. Accordingly, the present invention is to be considered as including all possible modifications and variations coming within the scope of the invention as defined by the appended claims.

What is claimed is:

1. A magnetic record comprising a substrate, a magnetic recording layer M disposed on the substrate, and adapted for magnetic transduction by associated passing transducer means; and at least one thin film R of non-magnetic material superposed adherently on layer M, and being no thicker than will degrade magnetic output from M minimally and only to a minor extent.
- 5 2. The record of claim 1 as adapted to be contacted, if only periodically, by slider transducer means.
3. The record of claim 1 where the outermost exposed film R is comprised of optical recording material and is adapted for optical data recording and readout.
4. The record of claim 1 wherein the outermost exposed film R is comprised of anti-wear material adapted for relatively non-attritive contact with transducer means.
5. The record of claim 2 wherein the substrate comprises a rotatable disk and wherein magnetic recording layer M comprises particles in a polymeric matrix.
6. The record of claim 4 wherein the substrate comprises a rotatable disk and wherein magnetic recording layer M comprises particles in a polymeric matrix.
7. The record of claim 3 wherein the outermost exposed film R is also adapted for relatively non-attritive contact with passing transducer means.

8. The record of claim 7 wherein the outermost exposed film R is also relatively non-corroding and is otherwise optically-stable in the prescribed contemplated user environments.

9. The record of claim 5 wherein the outermost exposed film R is comprised of relatively high-reflectance metal.

10. The record of claim 9 wherein the outermost exposed film R is also adapted for relatively non-attritive contact with passing transducer means and is also relatively non-corroding and is otherwise optically-stable in the prescribed contemplated user environments.

5

11. The record of claim 10 wherein films R are sputter-deposited onto layer M.

12. The record of claim 6 wherein films R are sputter-deposited onto layer M.

13. The record of claim 3 wherein at least the outermost exposed film R is relatively soft and apt to be damaged by contact with passing transducer means; and wherein this film R is coated with a thin non-magnetic metal layer H comprised of anti-wear material adapted for relatively non-attritive contact with passing transducer means.

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14. The record of claim 13 wherein films R and H are sputter-deposited.

15. A composite-optical record comprising a rotatable disk substrate, a magnetic data recording layer M disposed on the substrate, and comprising recording particulates dispersed in a polymeric matrix, layer M being adapted for transduction by associated slider-mounted transducer means and subject to be contacted, if only periodically, by associated slider means; and at least one thin film O of data "optical recording" material sputtered adherently onto layer M, and being up to several hundred 10 μ m thick, no thicker than will degrade output from M minimally and only to a minor extent, this material of O being adapted for optical data recording and readout with prescribed Write-beam and Read-beam means; there being an uppermost exposed film O_0 comprised of anti-wear material 15 adapted for relatively non-attritive contact with the slider means; there also being a lubricant layer L atop film O_0 .

16. The record of claim 15 wherein the outermost exposed film O_0 is also relatively non-corroding and is otherwise optically-stable in the prescribed contemplated user environments.

17. The record of claim 16 wherein the outermost exposed film O_0 is comprised of relatively high-reflectance metal.

18. The record of claim 17 wherein film(s) O is comprised of aluminum or chromium.
19. The record of claim 18 wherein the polymeric matrix comprises epoxy principally.
20. The record of claim 15 wherein at least the outermost exposed film O_o is relatively soft and apt to be damaged by contact with passing slider means; and wherein this film O_o is coated with a thin, hard, protective non-magnetic layer H comprised of non-optical anti-wear material adapted for relatively non-attritive contact with passing slider means; layer H also protecting layer O_o from corrosion and like chemical degradation of its reflectance, while being thin enough and sufficiently transparent to said Write-beam and Read-beam means to attenuate them insignificantly.
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21. A composit record comprising a rotatable disk substrate, a data recording layer M disposed on this substrate and presenting a high-smoothness surface, being adapted to be presented for contact or near-contact, at least periodically, with passing slider-transducer means and comprising recording particulates dispersed in a polymeric matrix; plus at least one thin film R of optical-recording material superposed adherently on the surface of layer M, the overall total thickness t_R of layers R being such as to degrade output from M only to a minor extent; at least the top, exposed layer R_o being comprised of optical recording material adapted for optical digital data recording with a prescribed Write-Beam and Read-beam means and also being either adapted for relatively non-attritive, non-damaging contact with said slider transducer means or else being covered by second supercoated film means H which is so adapted; there being a lubricant layer L atop film R_o .

22. The record of claim 21 wherein the uppermost film R_o furthest removed from layer M is comprised of high reflectance surface material.

23. The record of claim 22 wherein film R_o is adapted to be "pierced" by such optical recording in the course of recording a digital data "bit" with the underlying upper surface of layer M being of relatively low optical reflectance, sufficient to present good optical contrast and S/N.

24. The record of claim 23 wherein film(s) R comprise aluminum or chromium.

25. The record of claim 24 wherein film R_o is, itself, relatively hard, durable and adapted for such non-attritive contact.

26. The record of claim 24 wherein film R_o comprises sputtered chromium.

27. The record of claim 21 wherein one or several high-reflectivity films R_x are sputter-deposited on the surface of layer M.

28. The record of claim 27 wherein the high-reflectivity films R_x are supercoated with at least one thin protective film R_p of relatively hard material which is also relatively transparent to said Write-Beam and Read-beam, this material also being matched to the hardness of the sliding transducer surface; and also wherein the lubricant comprises a dry carbon deposit or like deposit.

29. The record of claim 28 wherein each protective film R_p is comprised of a carbide, a sulfite, or a suitable glass.

30. The record of claim 29 wherein the polymer comprises an epoxy and the films R are sputter-deposited thereon.

31. A method of fabricating a composite-optical record which includes a data recording layer M disposed on a substrate means, the layer M presenting a high-smoothness surface, adapted to be presented for periodic contact or near-contact with sliding transducer means and comprising recording particulates dispersed in a polymeric matrix, this method comprising:
5 depositing a thickness t_r of optical recording material R selected and applied to be adherent on said surface of M, this thickness t_r serving as optical recording means and also serving to protect the surface of M from damaging engagement with said transducer means, thickness t_r being sufficient to degrade signal output from M only to a minor degree, while also being coated with a lubricant and thus adapted for relatively non-attritive engagement with said transducer means, or 10 otherwise being coated with second protective film thickness R_p which is so adapted.
15

32. The method of claim 31 wherein thickness t_r is comprised of high-reflectivity metal adapted for said optical recording and sputter-deposited onto M, the reflectivity of the surface of layer M being substantially less than the reflectivity of films R; said lubricant comprising a dry carbon deposit or the like.
5

33. The method of claim 32 wherein thickness R_p comprises a carbide, a sulfide or a suitable glass.

34. The method of claim 32 wherein thickness t_r comprises aluminum or chromium.

35. The method of claim 31 wherein thickness t_r comprises chromium and no thickness R_p is employed.

36. The method of claim 31 wherein thickness t_r comprises aluminum and thickness R_p comprises a carbide, a sulfide or a suitable glass.

37. The method of claim 36 wherein R_p comprises SiC and the lubricant comprises a dry carbon deposit.

38. The method of claim 31 wherein protective layer R_p is used and serves to protect optical recording layer R_o with a harder coating, protecting against transducer contact as well as against tarnish or like optical degradation.

39. A product according to the method of claim 31.

40. A product according to the method of claim 32.

41. A product according to the method of claim 33.

42. A product according to the method of claim 34.

43. A product according to the method of claim 35.
44. A product according to the method of claim 36.
45. A product according to the method of claim 37.
46. A product according to the method of claim 38.
47. The record of claim 21 wherein optical recording film R₀ is coated with a thin transparent hardness film H adapted for relatively non-attritive non-damaging contact with said transducer means as well as relatively transparent to said optical recording.
5

48. A method of fabricating a magnetic-optical composite which includes a magnetic layer M disposed on substrate means and comprising magnetic particulates in a polymeric matrix, the layer M presenting a
5 high-smoothness surface and being adapted to be presented for periodic contact, or near-contact, with slider means, this method comprising:
sputtering about 100-200 Å° of non-magnetic
10 high-reflectance, optical material O to be adherent on the surface of M, at least the upper portion of this thickness t_o also serving to protect the surface of M from damaging engagement with said slider means, this thickness also being insufficient to degrade magnetic
15 output from M to any substantial degree while also being coated with a lubricant and adapted for relatively non-attritive contact with said slider means or else being coated with a second protective film thickness t_p which is so adapted.

49. The method of claim 48 where at least the upper exposed portion of thickness t_o is selected and adapted for such non-attritive contact.

50. The method of claim 48 where protective thickness t_p is sputtered upon thickness t_o .

51. The method of claim 48 wherein thickness t_o or $t_o + t_p$ aggregate up to several thousand Å° in thickness.

52. The method of claim 48 wherein optical thickness t_o comprises high-reflectivity aluminum or chromium and wherein a protective thickness t_p is superposed thereon, t_p comprising SiC, WC or MOS_2 and wherein the surface lubricant means comprises a dry carbon sputtered deposit.

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53. The method of claim 52 wherein thicknesses t_o , t_p and the carbon deposit each are on the order of 100-200 \AA , and wherein they total together no more than about 400-500 \AA .

54. The method of claim 48 wherein thickness t_o comprises about 100-300 \AA of aluminum sputter-deposited.

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55. The method of claim 48 wherein optical thickness t_o , protective thickness t_p and a lubricant layer are all successively applied, each being in the order of 100-300 \AA , with their aggregate thickness being no more than about 400-500 \AA .

56. The method of claim 55 wherein about 100-200 \AA of SiC or WC are RF sputter-deposited as thickness t_p .

57. The method of claim 48 wherein about 100-300 \AA of chromium is sputter-deposited to comprise thickness t_o .

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58. The method given in claim 57 wherein an initial thickness t_o for high optical reflectance is sputter-deposited on M to comprise about 100-200 \AA of Al or Cr; wherein about 100-200 \AA of SiC, WC or MOS_2 is sputter-deposited as protective thickness t_p on t_o and wherein a dry carbon deposit of 100-200 \AA is sputter-deposited on t_p as lubricant.

59. The method of claim 48 wherein an initial optical thickness t_o is applied on M comprising aluminum or chromium or nickel or rubidium or platinum or vanadium or tungsten or molybdenum or hafinum or gold or copper, and M comprises an epoxy matrix.

5 60. The method of claim 59 wherein a protective film thickness film thickness t_p is sputtered on t_o and adapted and/or treated so as to protect t_o with a harder coating adapted for slider contact and also adapted to protect against tarnish or like optical degradation of t_o .

61. The method of claim 60 wherein t_o comprises 100-200 Å of aluminum or chromium.

62. The method of claim 61 wherein t_p comprises 100-200 Å of SiC, WC or MOS_2 .

63. A method of making an optical-magnetic composite comprising:
applying a magnetic layer M onto a rotatable disk means,
layer M being selected and prepared to comprise
magnetic particles dispersed in a polymeric
matrix, and being adapted for magnetic
transduction by associated passing slider means
and adapted to be contacted, if only periodically,
by transducer slider means; and
superposing at least one thin film R of non-magnetic
optical material adherently on layer M, the
aggregate thickness of film(s) R being no more
than will degrade magnetic output from M
minimally and only to a minor extent.

64. The method of claim 63 where an outermost exposed film R_o is made to comprise high-reflectance optical material.

65. The method of claim 64 wherein the outermost exposed film R_o is also made to comprise anti-wear material adapted for relatively non-attritive contact with the slider means.

66. The method of claim 63 wherein film(s) R are made to comprise chromium or aluminum.

67. The method of claim 65 wherein the outermost exposed film R_o is also made relatively non-corroding and is otherwise optically-stable in the prescribed contemplated user environments.

68. The method of claim 63 wherein the outermost exposed optical film R_o is coated by at least one hard wear-film H.

69. The method of claim 68 wherein at least the outermost exposed film R_o is comprised of relatively high-reflectance metal, such as aluminum or chromium.

70. The method of claim 63 wherein the outermost exposed film R_o is also adapted, or is coated, for relatively non-attritive contact with passing slider means and is also relatively non-corroding and is otherwise optically-stable in the prescribed contemplated user environments.

5

71. The method of claim 63 wherein films R are sputter-deposited onto layer M.

72. The method of claim 68 wherein films R, H are sputter-deposited onto layer M.

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73. The method of claim 63 wherein at least the outermost exposed film R_o is relatively soft and apt to be damaged by contact with passing transducer means; and wherein this film R_o is coated with a thin non-magnetic metal layer H comprised of anti-wear material adapted for relatively non-attritive contact with passing slider means.

74. The method of claim 73 wherein films R and H are sputter-deposited.

75. A method of fabricating a magnetic-optical composite comprising:
sputtering magnetic layer M onto disk substrate means,
layer M being selected to comprise magnetic particulates dispersed in a polymeric matrix,
with surface portions of layer M being mirror-smooth and subject to being contacted,
if only periodically, by slider means;
sputtering one or more thin optical films R of
non-magnetic metal adherently on layer M and
of a thickness such as to degrade magnetic signal output from layer M only to a minor degree, at least the exposed one of film R_o being adapted for relatively non-attritive contact with said slider means; and
applying surface lube means on said film R_o.

76. The method of claim 75 wherein the hardness of film R_o is suitably matched to that of the slider means surface; the slider means including ferrite or thin film transducer means; and wherein film(s) R_o total up to a few hundred Å of an anti-wear carbide or sulfide material.

77. The method of claim 76 wherein the film R_o comprises dry deposited silicon carbide, tungsten carbide, or a molybdenum sulfide.

78. The method of claim 77 wherein the surface lube means comprises up to a few hundred A° of sputtered dry carbon.

79. The method of claim 75 wherein the total thickness of film(s) R degrades magnetic signal output only about 20% or less.

80. The method of claim 75 wherein the surface lube means comprises a wet lubricant film.

81. The method of claim 75 wherein films R comprise chromium or aluminum.

82. The method of claim 75 wherein film R_c comprises silicon carbide and wherein the carbon deposit is epitaxially influenced by this silicon carbide.

83. The method of claim 75 wherein film R_o comprises a thin deposit of glass or a carbide or a sulfide.

84. The method of claim 83 wherein film R_o comprises a carbide and wherein layer M comprises a metal which is plated or sputtered onto the substrate means, and wherein the lube means comprises a dry carbon deposit.

85. The method of claim 84 wherein layer M comprises Co-Ni-P and wherein film R_o comprises silicon carbide.

86. The method of claim 85 wherein the silicon carbide and the carbon lube are both sputter-deposited.

87. The method of claim 75 wherein film(s) R comprise aluminum or chromium or nickel or rhodium or platinum or vanadium or tungsten or molybdenum or hafnium, or alloys thereof.

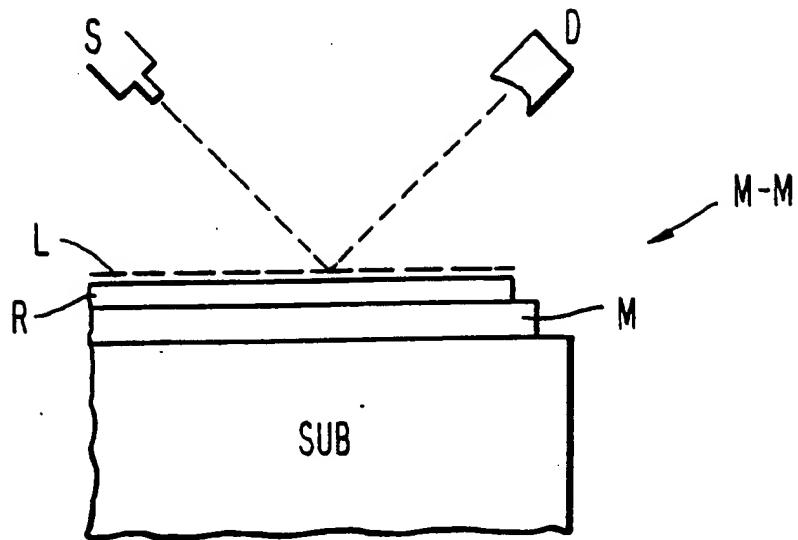
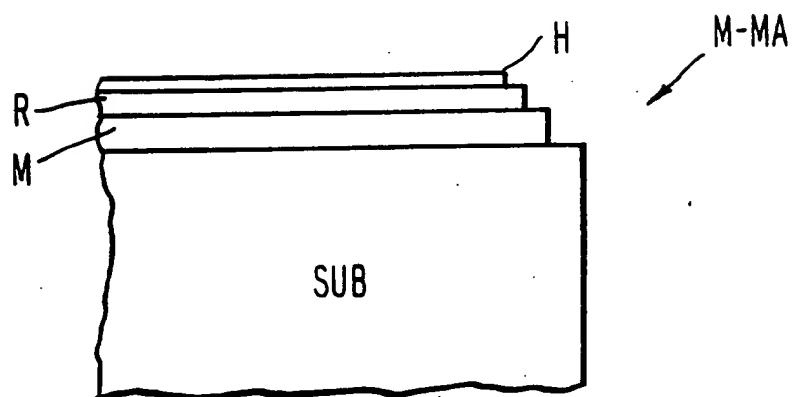
88. The method of claim 87 wherein film(s) R aggregate up to several thousand Å in thickness.

89. The method of claim 75 wherein optical film(s) R comprise high-reflectivity aluminum or chromium, and wherein a protective film or films R_p is superposed thereon, film(s) R_p comprising SiC, WC or MOS_2 ; and wherein the surface lube means comprises a dry carbon deposit.

90. The method of claim 89 wherein the thickness of films R_o , R_p and the carbon deposit each in the order of 100-200 \AA° , totalling together no more than about 400-500 \AA° .

91. The method of claim 75 wherein, for film(s) R,
about 100-200 Å° of non-magnetic optical material is
sputtered to be adherent on the surface of M, this
material also serving to protect the surface of M from
damaging engagement with said transducer means, the
aggregate thickness of R also being insufficient to
degrade magnetic signal output from M to any
substantial degree while also being coated with a second
protective film thickness R_p which is adapted for
non-attritive contact with the slider means.

1/1

Fig.1Fig.2

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 87/02243

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC⁴: G 11 B 5/72; G 11 B 11/10

II. FIELDS SEARCHED

Minimum Documentation Searched ?

Classification System	Classification Symbols
IPC ⁴	G 11 B

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched *

III. DOCUMENTS CONSIDERED TO BE RELEVANT*

Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	US, A, 4277540 (H. AINE) 7 July 1981 see abstract; column 3, lines 59-64; column 4, lines 39-51	1,2,4
Y	--	7-11,13- 18,20-29, 31-79,81, 83,87-89.
X	FR, A, 2561023 (CANON K.K.) 13 September 1985 see claims 1-11	1,3. 7-11,13- 18,20-29, 31-79,81, 83,87-89
Y	--	
A	EP, A, 0064129 (IBM) 10 November 1982 see claim 1; page 1, lines 4-11	5,6,19,30 59
X	--	
X	US, A, 4411963 (H. AINE) 25 October 1983 see claims 1-3,13,16-18	1,2,4,78, 84
	--	./. .

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"Z" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

7th November 1987

Date of Mailing of this International Search Report

22 JAN 1988

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FR M THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	Computer Design, volume 23, no. 4, April 1984, (Winchester, Massachusetts, US), J.H. Smith: "Thin-film media meet increased storage demands", pages 273-281 see pages 273-274	5,6,19, 30,59

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. US 8702243
SA 18610

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 06/01/88
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